Teaching an Engineering Systems Doctoral Seminar: Concepts and Structure

Second International Symposium on Engineering Systems

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Background

- Engineering Systems (ES) is an evolving field spanning engineering, management, & social sciences
  - What is testable "common knowledge" for ES?
- The MIT Engineering Systems Doctoral Program requires a sequence of 3 core courses
  - ESD.83 Doctoral Seminar in ES
  - ESD.86 Data, Models & Inference for Socio-technical Systems
  - ESD.87 Social Science Research Methods
- Doctoral Seminar intended to facilitate transition from ES student to ES scholar

This presentation provides a "current state" view of the ES Doctoral Seminar at MIT

Pedagogy

- ES problems are multi-disciplinary and do not have simple right/wrong answers
- What to teach?
  - Wide diversity of topics; invited guest speakers
  - Multi-modal thinking (visual, numerical, etc.)
  - System representations (frameworks & models)
- How to teach?
  - Active learning; peer interactions emphasized
  - Leverage diversity of student backgrounds

Yearly Topics (2008)

Week 1	Introduction	Overview of past ES Symposium Literature
Week 2	Introduction	MIT ESD leadership perspectives, ES Themes
Week 3	Foundations	Emergence of ES as a field, historical perspectives on ES
Week 4	Context	A systems approach to safety
Week 5	Foundations	Uncertainty & flexibility: Scenario planning & Real options
Week 6	Foundations	Human nature and organizational systems
Week 7	Foundations	Complexity theory, agent models and economics
Week 8	Mid-term Review	Student presentations
Week 9	Foundations	Regulations, standards and protocols
Week 10	Context	Cities as complex systems
Week 11	Foundations	Networks and critical infrastructures
Week 12	Context	Energy and environmental analysis
Week 13	Foundations	Views of strategy
Week 14	Context	A systems approach to healthcare
Week 15	Conclusion	Architecting ES as a field of study

*Shading provides visual indicator for the number of foundation and context sessions

Typical Session: Week 5 (10/1/08)

- Topic: Uncertainty and Flexibility
- Required pre-readings (~100 pages)
  - Real options (de Neufville)
  - Scenario planning (RAND, Wack)
- Redactor Summary & Discussion (30 min)

Summary of class questions for week 5

	Category	Number of Questions
I	Definition of value	4
II	Applicability and merits of real options	6
III	Theory of real options analysis	10
IV	Practical implementation of real options	15
V	Questions about screening models	2
VI	Design, analysis, and relative merits of scenario planning	6
	TOTAL:	43

Typical Class Session: Week 5

- Guest Lecture & Discussion (60 min)
  - de Neufville on Real Options
- Student Book Review & Discussion (20 min)
  - Hughes, *Rescuing Prometheus*
- Report from the Front (15 min)
  - "Testing metal: When thinking globally requires unpleasant action locally," 9/29/08, The Economist
- Instructor Lecture (45 min)
  - Sussman on Scenario Planning

Observations

- Course evaluations highlight the difficulty of achieving the appropriate balance
  - Depth vs. breadth of topics
  - Accommodation of diverse student backgrounds
  - Controlling “scope creep” as ES evolves & matures
- Individual meetings with students at the end of the semester provides a valuable opportunity for coaching and feedback
- Generally, course is seen as valuable by participating faculty and students

Questions?

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Themes & Key Concepts

- Active learning environment
- Systems thinking
  - Multi-modal thinking
  - System representations
- The nature of design in ES
  - Socio-technical complexity
  - The “ilities” and Critical contemporary issues
- Advancement of the ES field
- Diversity of perspectives; guest lecturers
- Weekly sessions roughly categorized topically as ES foundations or ES context

Learning Objectives

1) Basic Literacy	Understand core ES concepts and principles of the ES field
2) Historical Roots	Understand the intellectual roots of key concepts and principles and historical emergence of the ES field
3) Interdisciplinary Capability	Ability assess the importance and relevance of new findings in adjacent fields to ES
4) Linkages Across Domains	Ability to identify links and connections across different domains relevant to ES
5) ES Data Sources	Ability to professionally search for relevant data sources and assess their potential value in ES research
6) Critical Analysis	Ability to critically assess ES research and scholarship and develop defendable POV
7) Scholarly Skills	Ability to communicate scholarly inquiry and contributions in common formats

Assignments (2008)

Assignment title	Deliverable	**Learning Objectives**
Engineering systems data sources and representations	Paper & presentation	1, 4, **5**, 6, 7
Report from the front	Presentation	1, **3**, 5, 7
Redactor role	Paper, presentation & facilitated discussion lead	1, **4**, 6, 7
Book review	Paper, presentation & facilitated discussion lead	3, 4, **6**, 7
Engineering systems historical roots	Paper	**2**, 4, 6, 7
Developing a well-formed research question	Paper	3, 4, 5, 6, **7**
Learning summary	Paper	**1**, 2, 4, 6

*Shaded assignments recur throughout the semester;
Bolded numbers indicated learning objective emphasis

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Typical Weekly Activities

- Mondays
  - Instructor coordination meeting
- Tuesdays
  - Reading questions due to student redactor
- Wednesdays
  - Class meets
  - 3 hours per session
  - Reading assignments posted for next session
- Fridays
  - Teaching assistant led discussion group
  - 1 hour per session

Typical Session

Activity	Leader	Duration
Introduction and objectives	Faculty	5-10 min.
Redactor presentation and discussion	Student	25 min.
Guest presentation and discussion	Guest	60-75 min.
Break		10 min.
Book review and discussion	Student	15-20 min.
Report from the front and discussion	Student	15 min.
Instructor presentation	Faculty	15 min.
Next steps and class logistics	Faculty	5 min.

*Shading indicates student-led portions of the class